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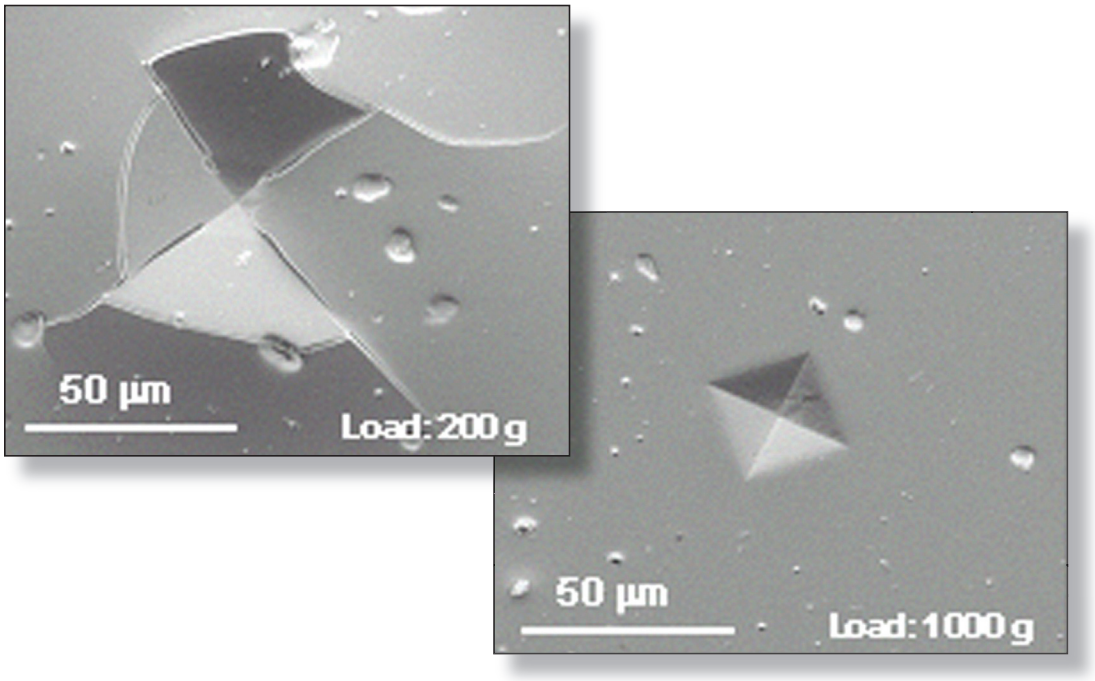
Science and Technology for Tomorrow's Air and Space Force

Success Story

ADVANCEMENTS IN SUPER-TOUGH NANOCOMPOSITE COATINGS POINT TO IMPROVED AIRCRAFT ENGINE PERFORMANCE AND DURABILITY



Materials and Manufacturing Directorate scientists and engineers, working with university researchers, have made substantial progress in the understanding of super-tough nanocomposite coatings. These new coatings could be used to improve the performance and durability of advanced jet fighter aircraft engine components.

As a result of this research effort, the directorate is exploring new application possibilities within the Air Force and seeking avenues to transfer the new materials to the aerospace community. One possible transition path leads to the use of nanocomposite coatings in short take-off and vertical landing (STOVL) propulsion system components, where friction pairs are heavily preloaded and can benefit significantly from surface strengthening.

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Accomplishment

The directorate team identified a dynamic mechanism unique to nanocrystalline/amorphous composites, highly valued by aerospace engineers for their extreme hardness. The research has led to increased opportunities for transitioning new materials to combat aircrafts, a Small Business Innovation Research (SBIR) Phase I program to improve the structural and performance capabilities of aircraft propulsion systems and a number of possible commercial applications.

Background

Researchers in the directorate's Nonmetallic Materials Division of the Nonstructural Materials Branch initially developed a new class of wear-resistant materials for friction pairs of air and space vehicles. These materials are made of very hard, 3–5 nanometer (nm)-sized grains of carbides or oxides embedded into an amorphous matrix of either diamond-like carbon or a metal/ceramic mixture. During this preliminary stage, the research revealed an unusual combination of high hardness, exceeding that of ceramics and fracture strength similar to that of tough metal alloys.

Building on this discovery, the directorate teamed with university researchers to set up one-of-a-kind experiments. New composite materials could be mechanically tested inside a transmission electron microscope column to observe with nanometer-level resolution what mechanisms are responsible for the unusual combination of mechanical properties.

As a result of this investigation, a new mechanism of macroscopic ductility was found for these tough nanocomposites. This new mechanism is a unique feature of nanocrystalline/amorphous composite design since it is tied to a great number of 1–2 nm shifts of nanograins inside an amorphous matrix.

The experimental results of this research effort explain the high fracture toughness of nanocrystalline/amorphous composites at extreme contact deformations with high loading rates. Currently, directorate scientists and engineers are exploring a wide range of nanocomposite coatings application possibilities for military aircrafts. They are also searching for innovative technology transfer opportunities. One transfer possibility involves the use of nanocomposites in STOVL frictional propulsion system components. An SBIR program has been initiated to address this opportunity.

Materials and Manufacturing
Emerging Technologies

Additional information

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